Fig. 1
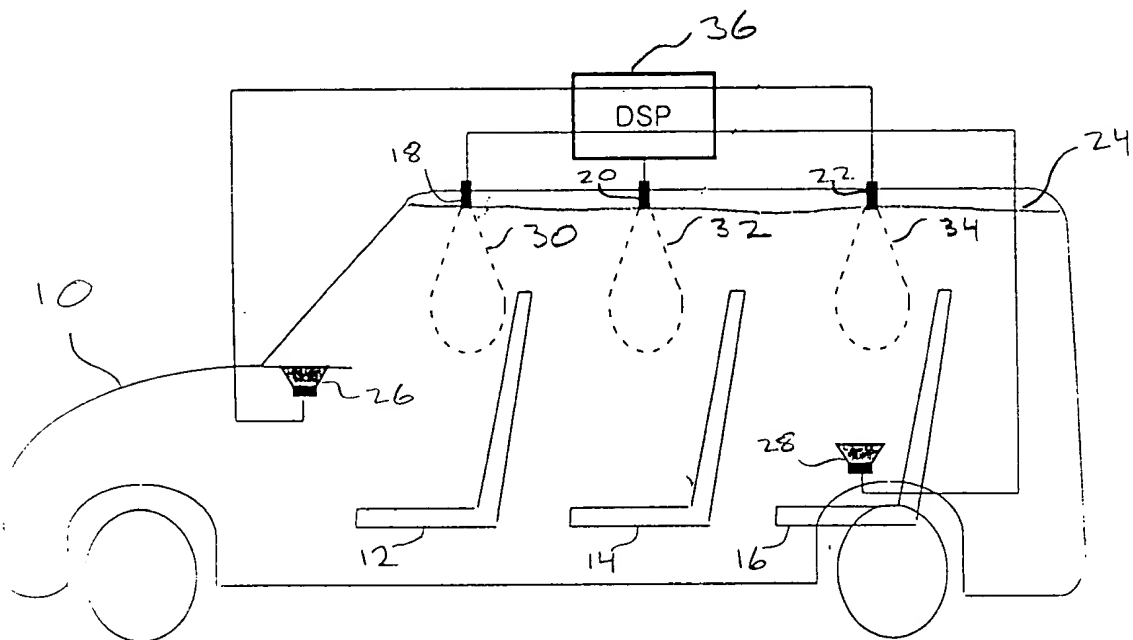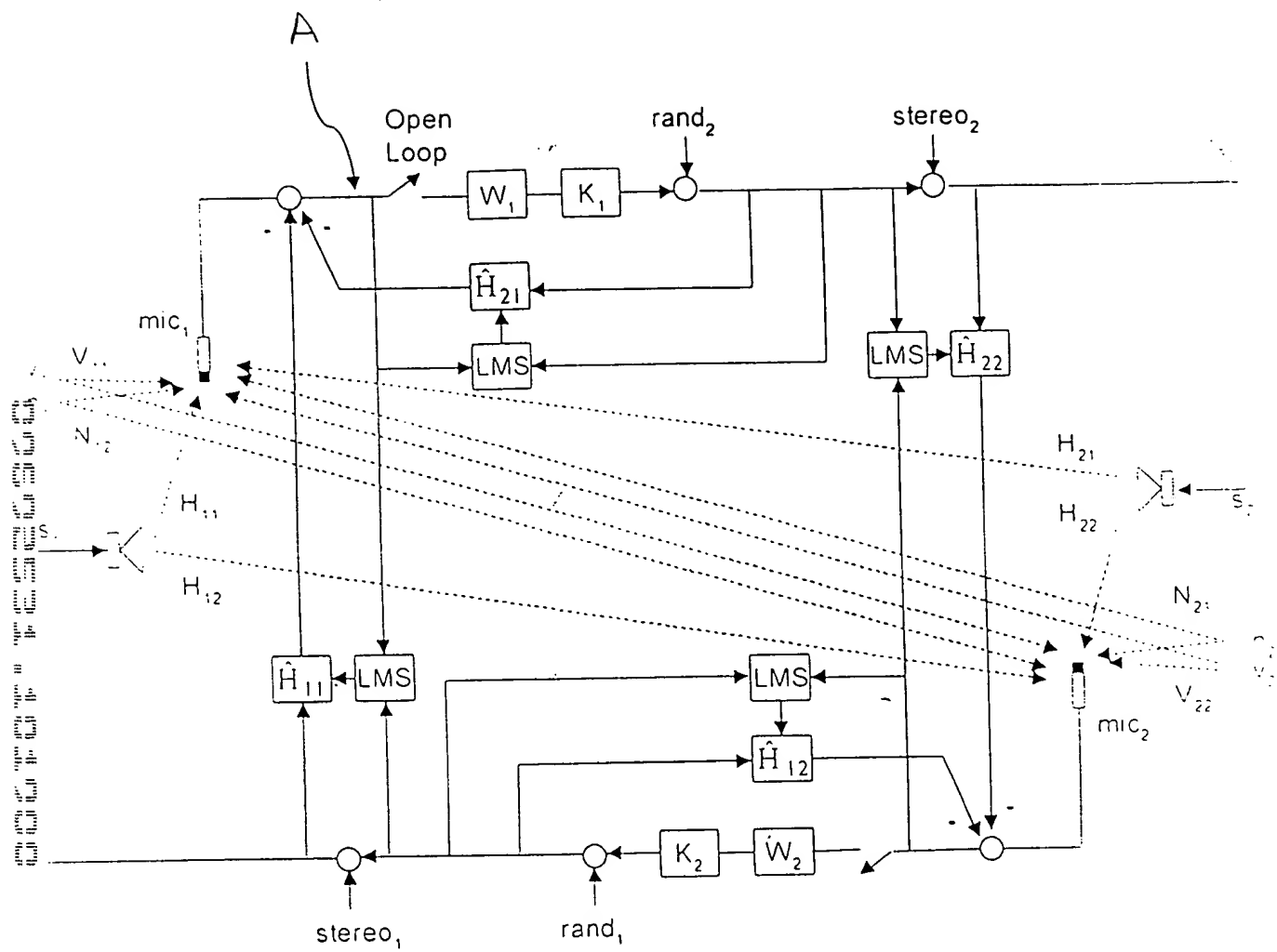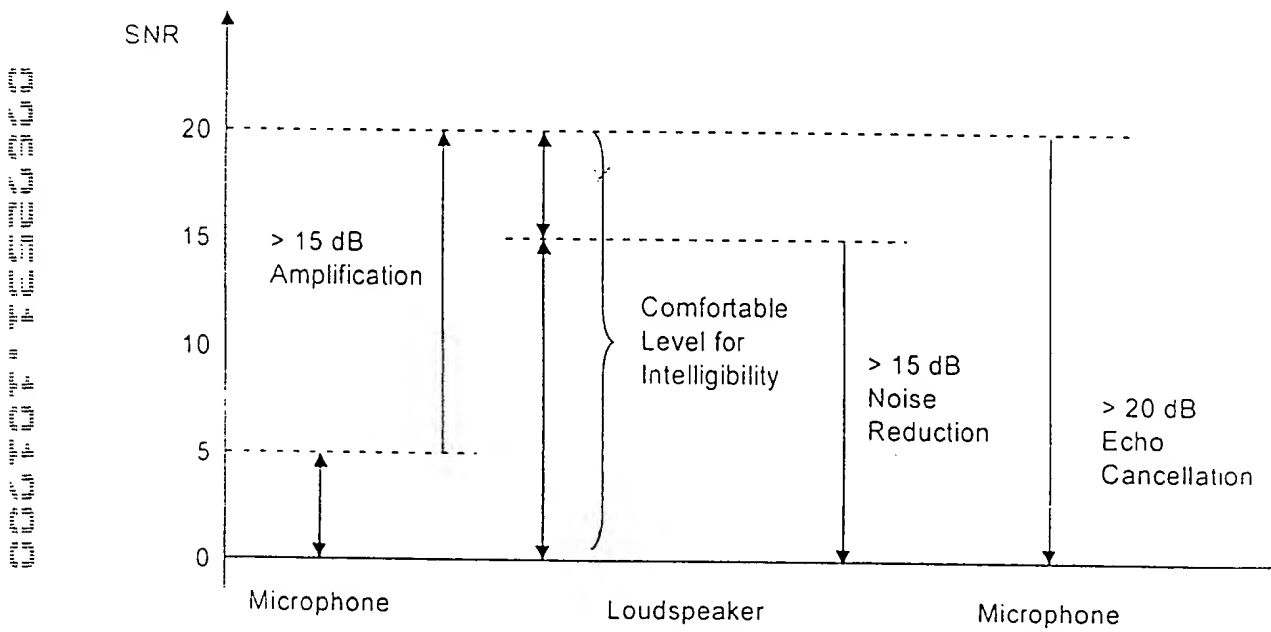
Fig. 2

Fig. 3

Fig. 4
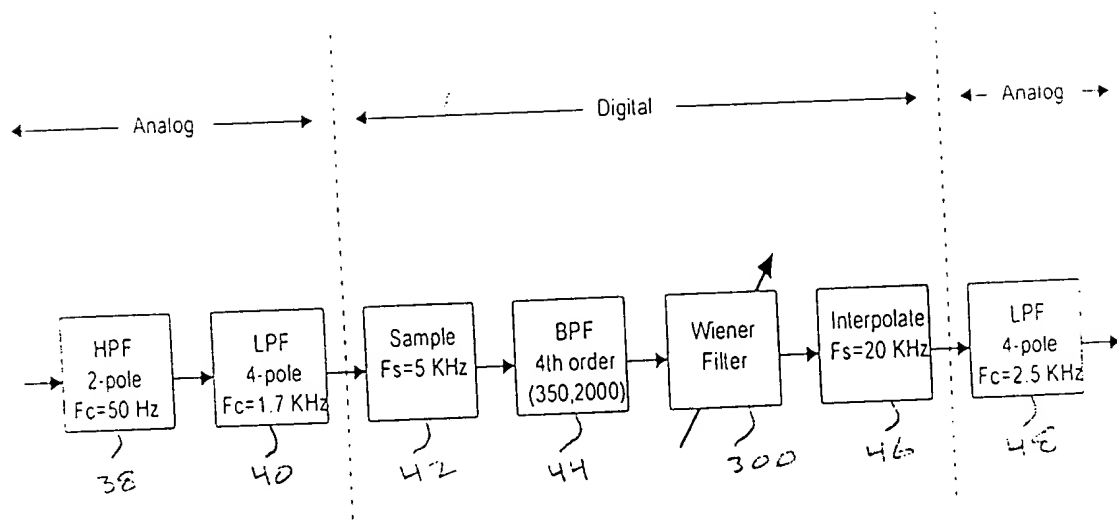
← Analog → | ← Digital → | ← Analog →

```
┌──────────┐   ┌──────────┐   ┌──────────┐   ┌──────────┐   ┌──────────┐   ┌──────────┐   ┌──────────┐
│   HPF    │   │   LPF    │   │  Sample  │   │   BPF    │   │  Wiener  │   │Interpolate│  │   LPF    │
│  2-pole  │→  │  4-pole  │ → │  Fs=5 KHz│ → │ 4th order│ → │  Filter  │ → │ Fs=20 KHz│ → │  4-pole  │ →
│ Fc=50 Hz │   │Fc=1.7 KHz│   │          │   │(350,2000)│   │          │   │          │   │Fc=2.5 KHz│
└──────────┘   └──────────┘   └──────────┘   └──────────┘   └──────────┘   └──────────┘   └──────────┘
     38            40              42             44            300            46             48
```
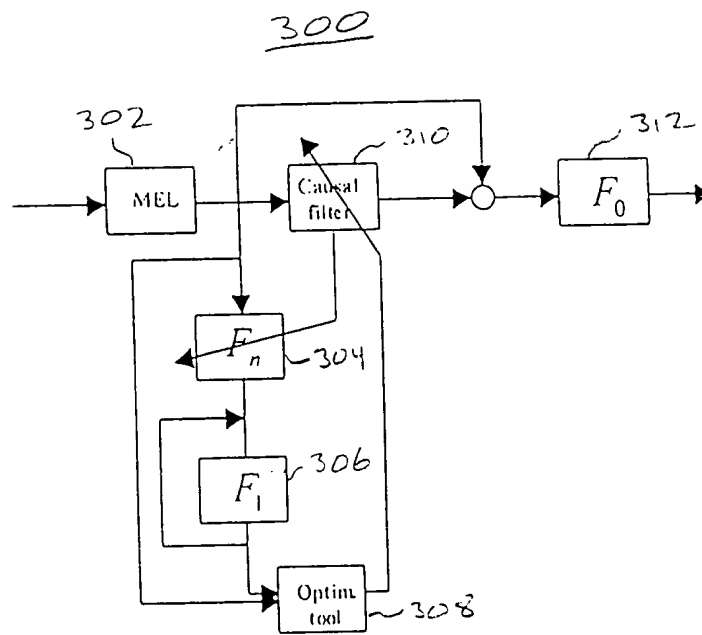
Fig. 5
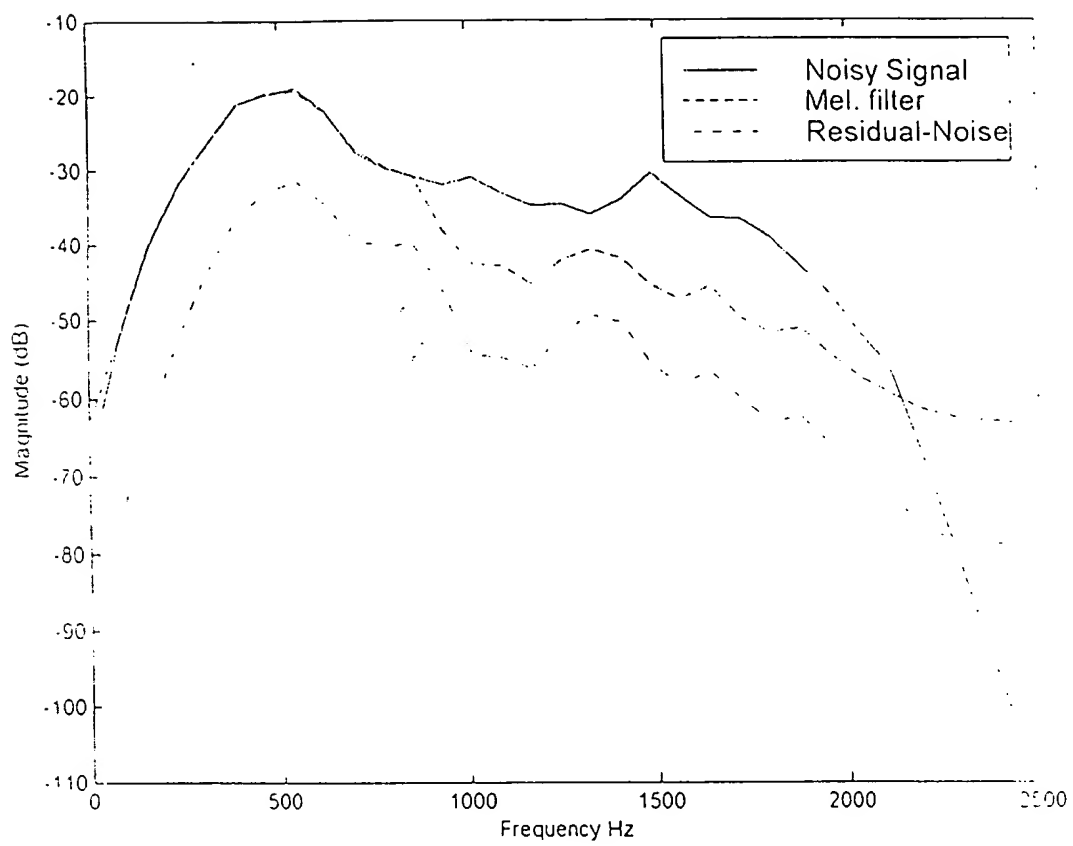
300

302

MEL

310

Causal
filter

312

F_0

F_n 304

F_1 306

Optim.
tool 308

Fig. 6

Fig. 7

Fig. 8

Fig. 9

Fig. 10

400

Microphone

Signal to
Loudspeaker

Tapped Delay

∎ ～ 200

x   x   x

Σ

－ ～ 210

40ω

Coefficients (h)

$h(t+1) = h(t) + \mu\, e\, x$

404

Σ

Error Signal e

Regressor (x)

X

μ

402

Fig. 11

500

To Mixer, Amplifier,
and Loudspeaker
u(t)

Ambient Noise
n(t)

Microphone
s(t) = n(t) + ...

~200

506

400

Echo Canceller (H)

Σ ~210

Random Noise

Σ

508

Stereo Gain Estimator

504

502

From Car
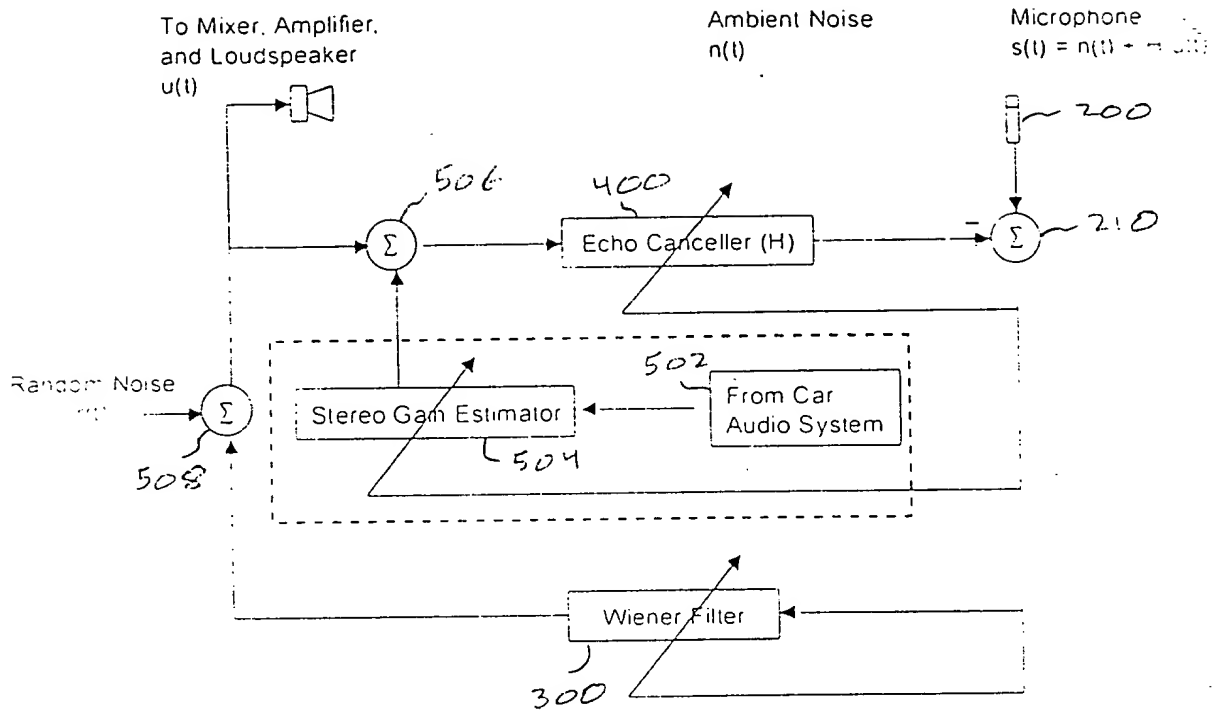Audio System

Wiener Filter

300

Fig. 12

```
m=20;delays=30;sig=.00;n=170;
y=filter(h,1,r)+sig*n;
htp1=ht(1:delays+m);
pn=eye(m);
L=length(ht);
ind=delays+m:m:n;
lind=length(ind);
kg=zeros(m,(lind-1)*m+1);

for j=1:lind
ind0(1:m,j)=[(j-1)*m+1:j*m]'+delays;
end
htemp=ht(ind0);

for k=200:10000
ind1=k-ind0;
[htemp(:,1),k0,pn,an]=rls1(pn,y(k-1),r(ind1(:,1)),htemp(:,1),1);

for l=(lind-1)*m:-1:1
kg(:,l+1)=kg(:,l);
end

kg(:,1)=k0;

for j=2:lind
htemp(:,j)=htemp(:,j)+kg(:,(j-1)*m+1)*(an-htemp(:,j)'*r(ind1(:,j)));
end
```
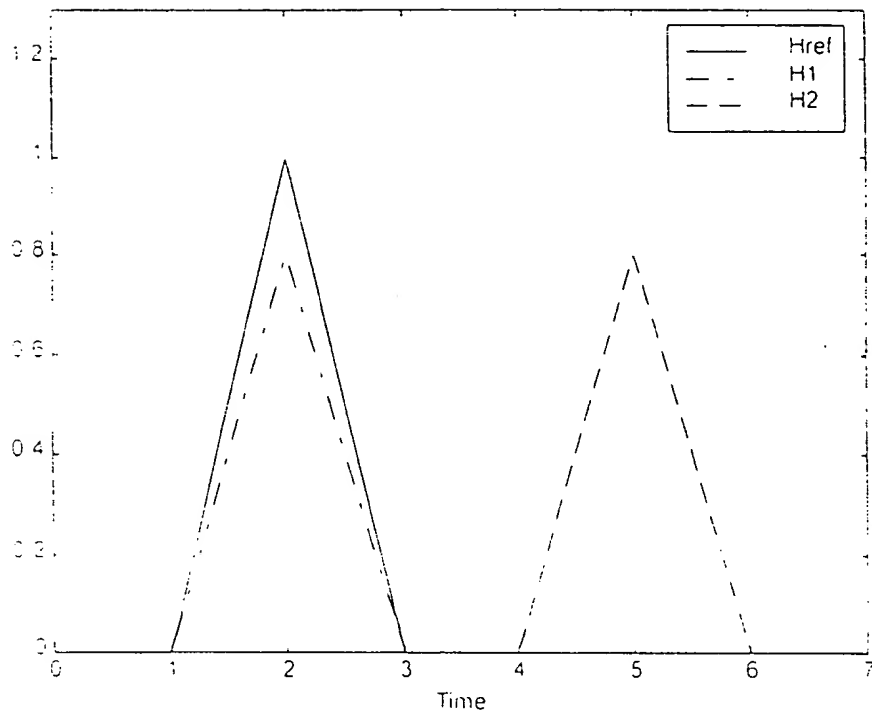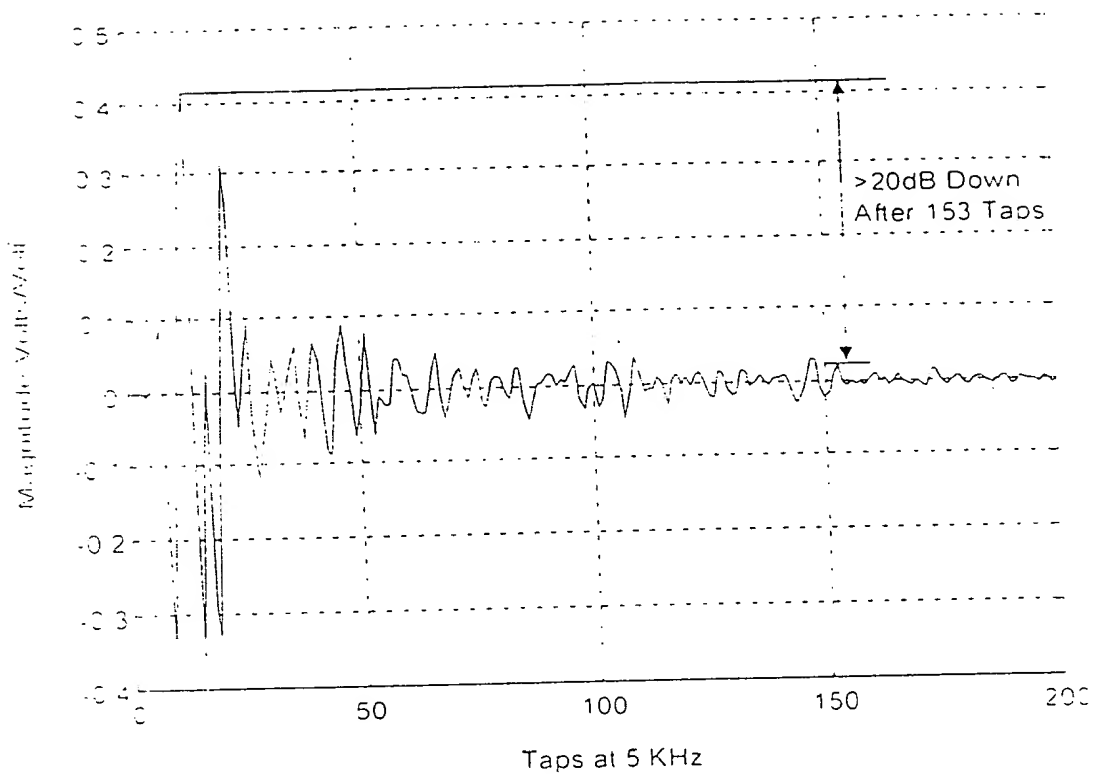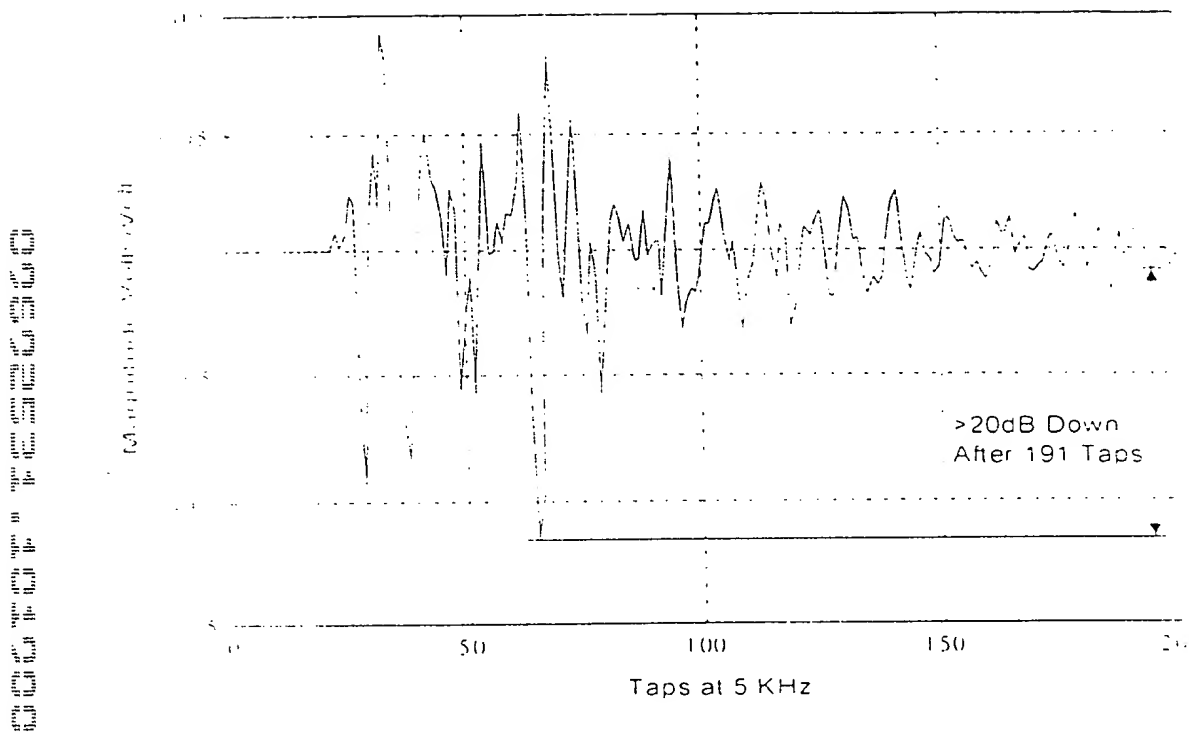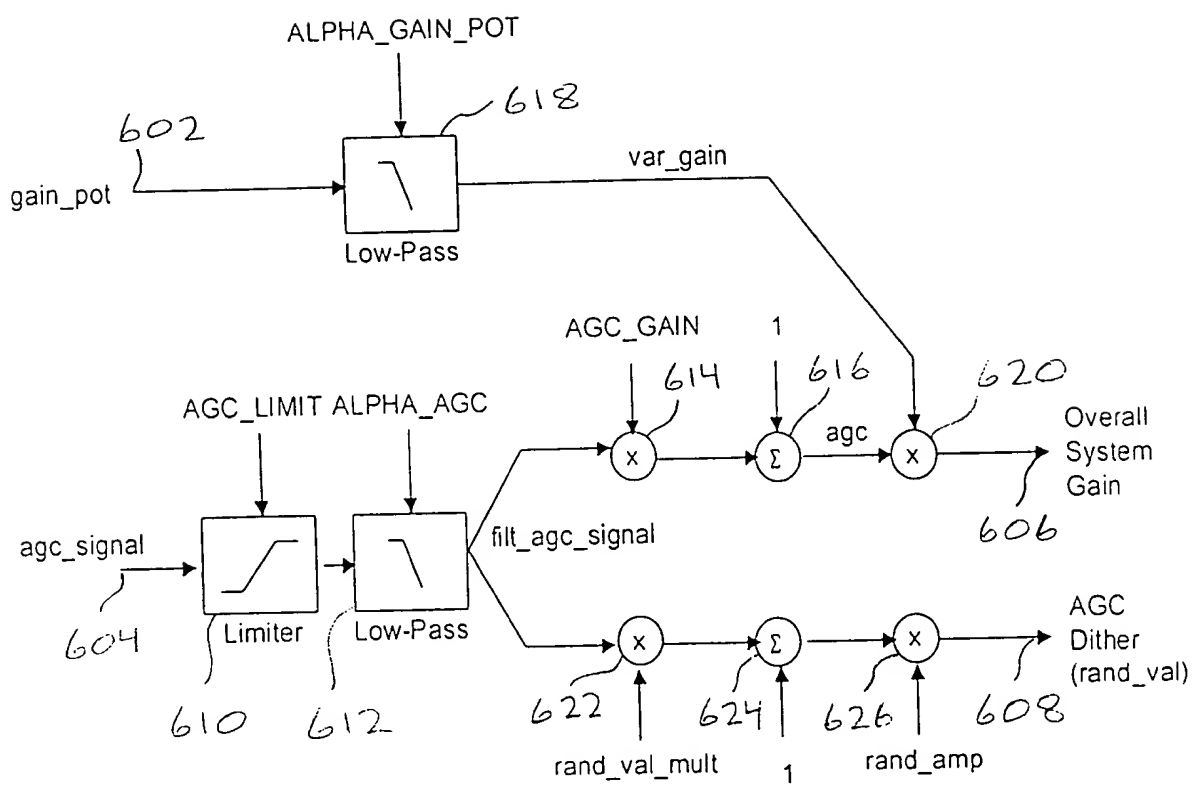
Fig. 13

Fig. 14

Fig. 15

Fig. 16

$\underline{600}$

Fig. 17

Fig. 18

AGC_GAIN   1

628   630

filt_agc_signal ──────────▶ X² ──▶ X

632   634

AGC_SQUARE_GAIN
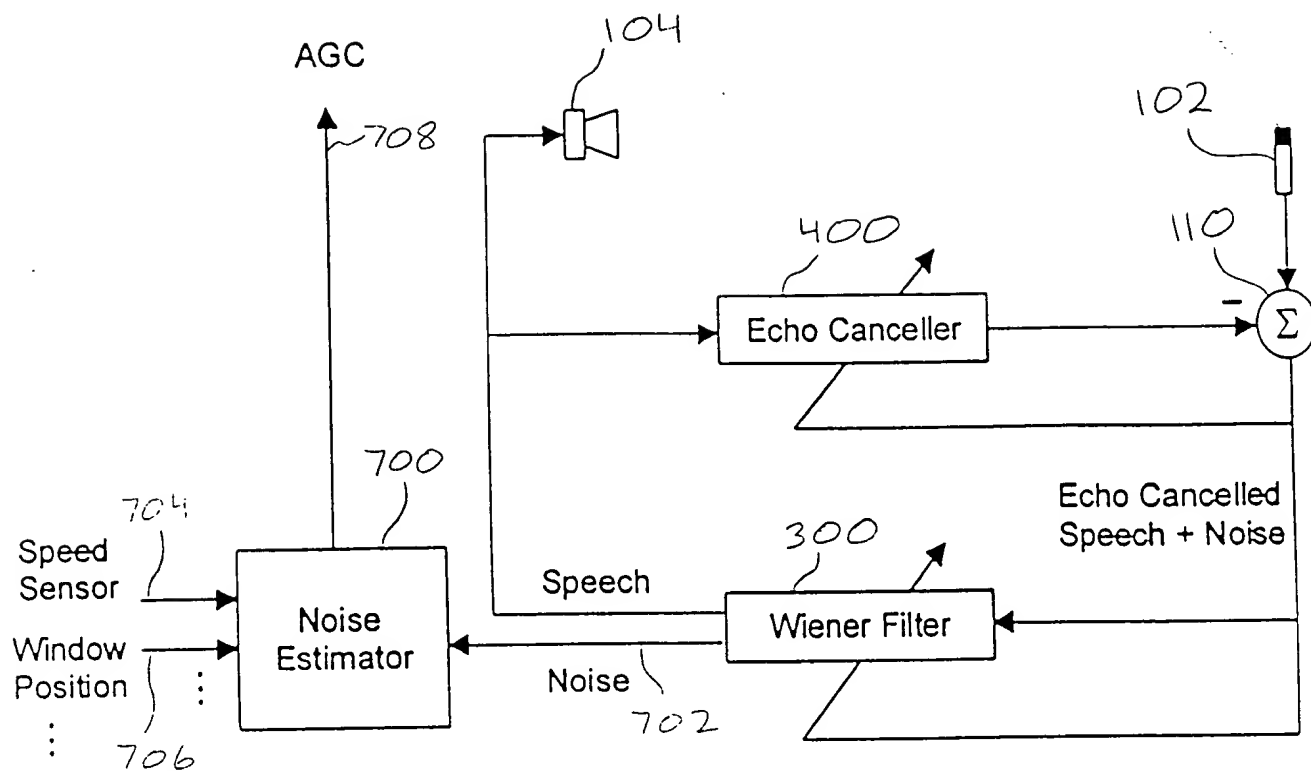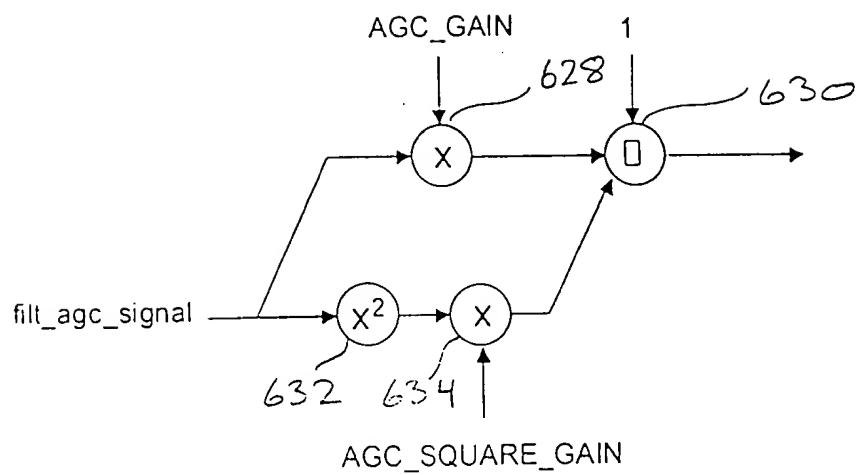
Fig. 19

Cabin
Noise
Estimate
From Known
Factors

750a

752a

Individual
Microphone
Noise
Estimates
from
Wiener SEF

750b

752b

750i

754

752i

−

758

756

Limiter

Cabin
Ambient
Noise
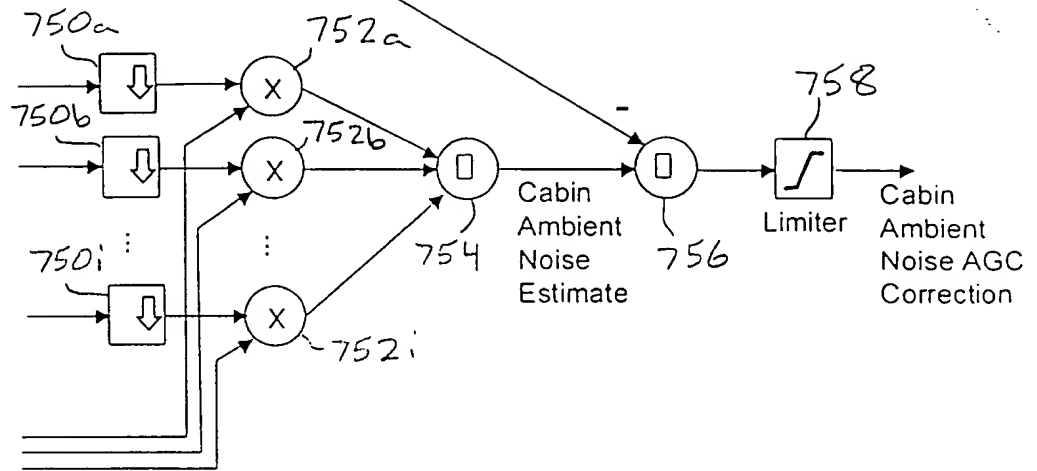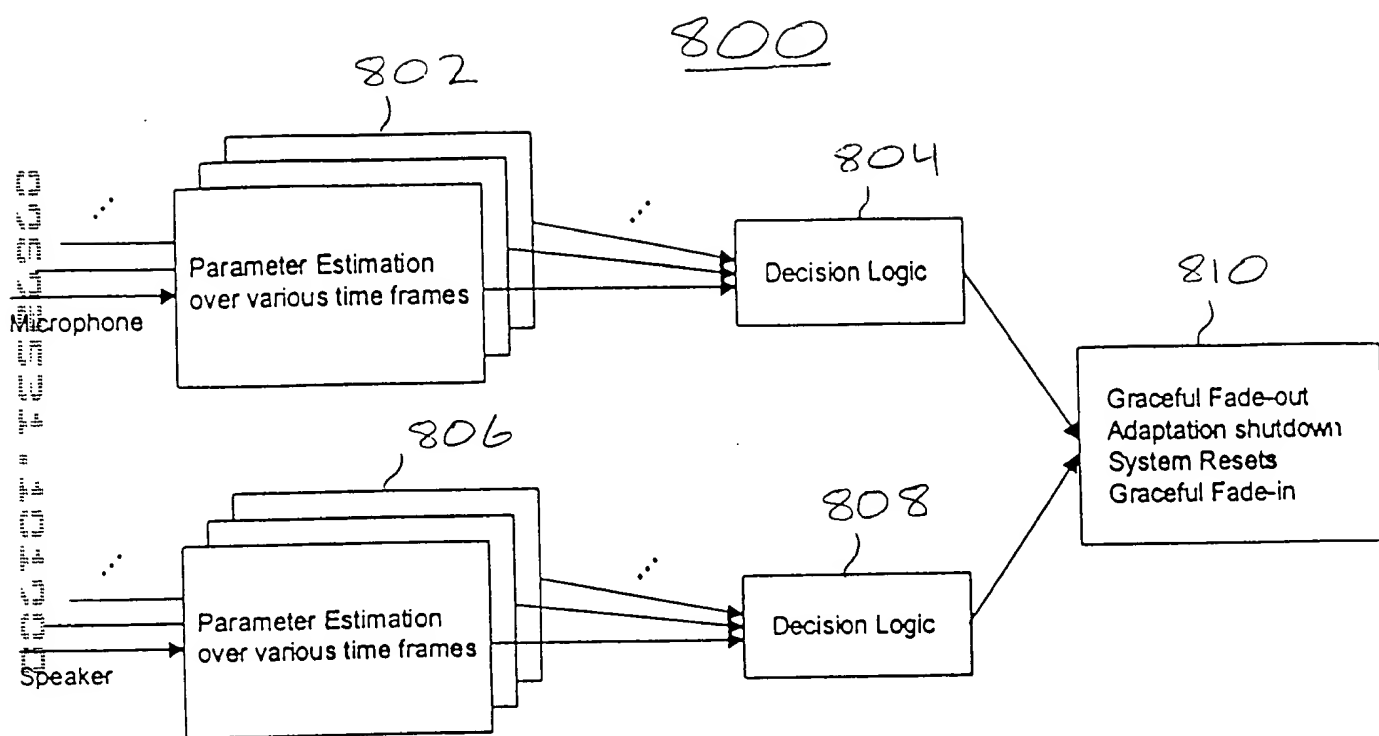Estimate

Cabin
Ambient
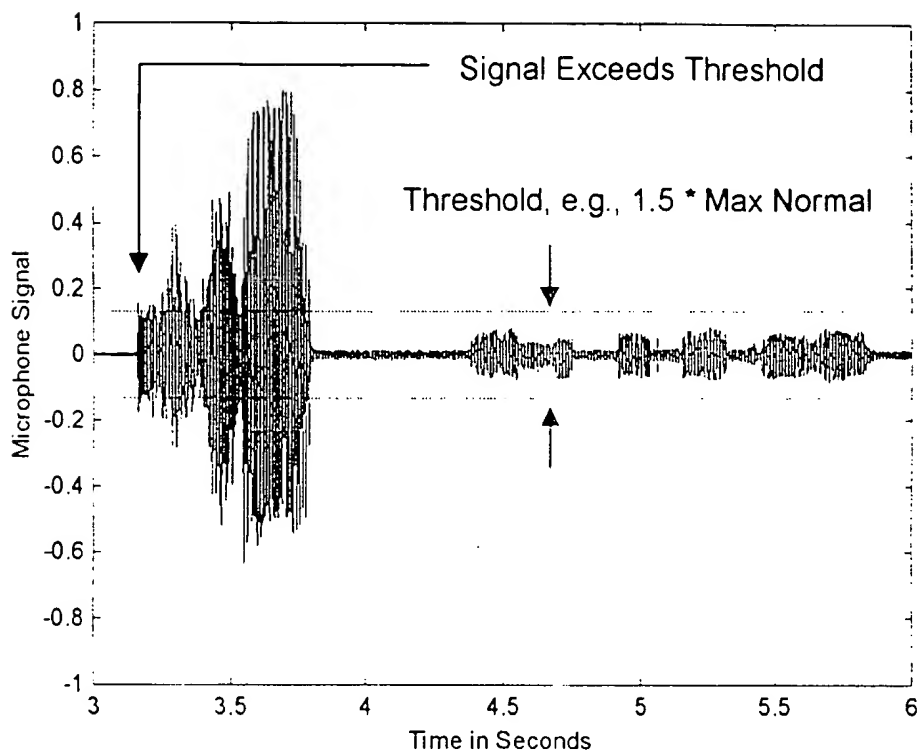Noise AGC
Correction

Individual
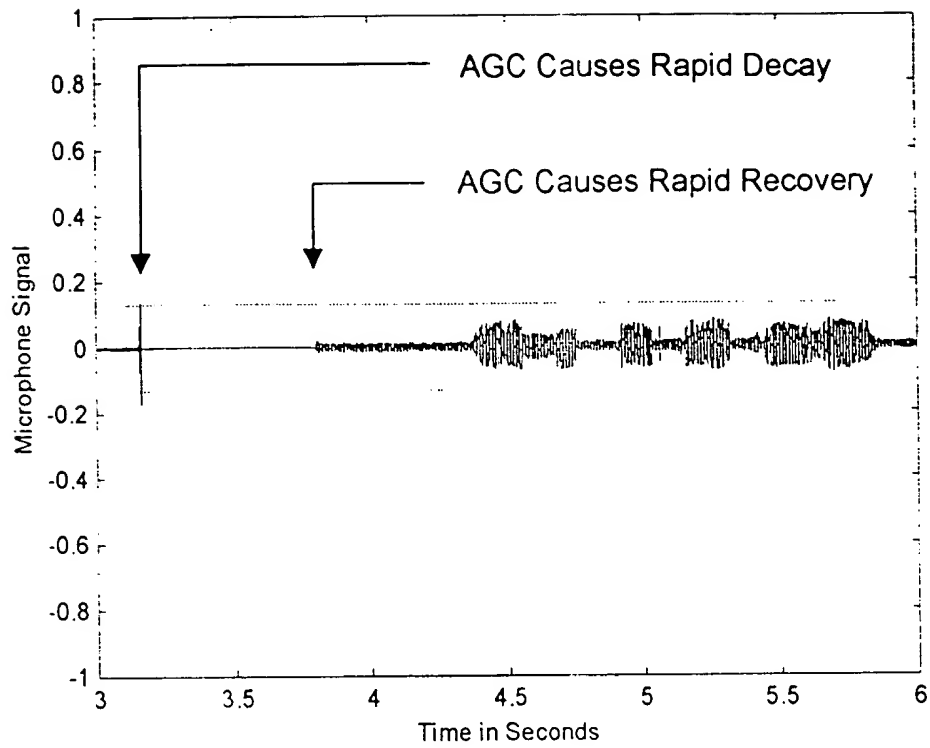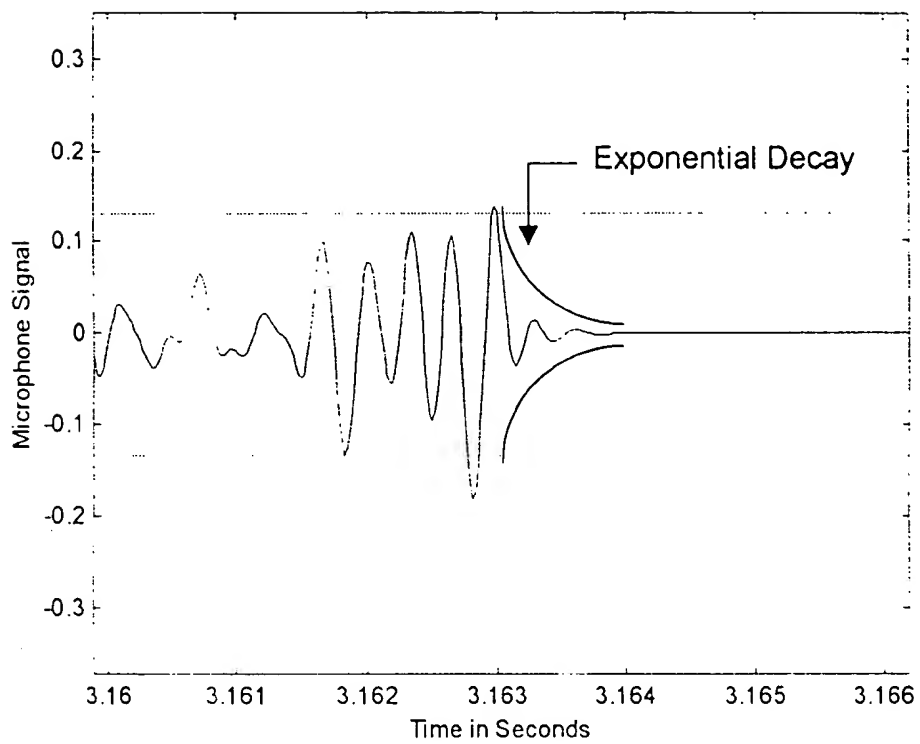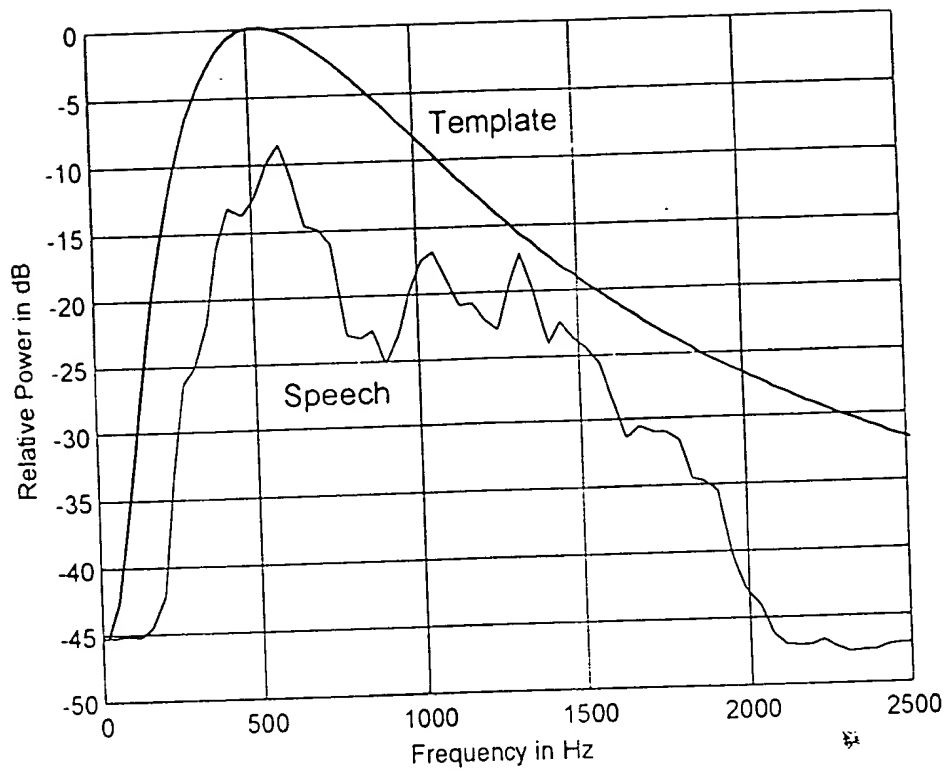Microphone
Average
Level
Compensation

Fig. 20

Fig. 21

Fig. 22

Fig. 23

Fig. 24

Fig. 25

900

Cabin Communication System

912
Record

914 Playback

Talk front to rear
916

Listen rear to front
918

920 Volume rear to front

Participate in Cell Phone Call
922

User
Interface
Front
910

User
Interface
Rear
930

950
User
Interface
Middle

Record 932

Playback 934

Talk rear to front 936

Listen front to rear 938

940 Volume front to rear

Participate in Cell Phone Call

942

Fig. 26

Fig. 27

Fig. 28